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Review Article

Benign tumours of the bone: A review ☆

David N. Hakim [a], Theo Pelly [b], Myutan Kulendran [c], Jochem A. Caris [d]

[a] Imperial College London, UK
[b] Leeds University, UK
[c] St George's Hospital,UK
[d] Academic Surgical Unit, Imperial College London, UK

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ABSTRACT

Benign tumours of the bone are not cancerous and would not metastasise to other regions of the body. However, they can occur in any part of the skeleton, and can still be dangerous as they may grow and compress healthy bone tissue. There are several types of benign tumours that can be classified by the type of matrix that the tumour cells produce; such as bone, cartilage, fibrous tissue, fat or blood vessel. Overall, 8 different types can be distinguished: osteochondroma, osteoma, osteoid osteoma, osteoblastoma, giant cell tumour, aneurysmal bone cyst, fibrous dysplasia and enchondroma.

The incidence of benign bone tumours varies depending on the type. However, they most commonly arise in people less than 30 years old, often triggered by the hormones that stimulate normal growth. The most common type is osteochondroma.

This review discusses the different types of common benign tumours of the bone based on information accumulated from published literature.

1. Introduction

Benign tumours of the bone consist of a wide variety of different neoplasms. These tumours vary in terms of incidence, clinical presentation and require a diverse array of therapeutic options. The incidence of benign bone tumours is debated due to their often asymptomatic presentation and difficulty in detection [1]. Overall, 8 different types can be distinguished; osteochondroma, osteoma, osteoid osteoma, osteoblastoma, giant cell tumour, aneurysmal bone cyst, fibrous dysplasia and enchondroma. These tumours can be roughly divided into categories based on their cell type: bone-forming, cartilage-forming, as well as connective tissue and vascular [2]. Some other forms of benign tumours may also present, however due to their low incidence they will not be discussed. We will discuss the most common first followed by descending prevalence.

2. Osteochondroma

These cartilaginous tumours represent most of the benign bone tumours (approx. 30%). Most commonly found in the femur and tibia, osteochondroma occur mainly in the metaphysis and diametaphysis and projects out of the underlying bone. The cartilaginous cap is the site of growth, which normally diminishes after skeletal maturity. Whilst solitary osteochondroma (exostosis) is normally encountered within the first four decades [3], the hereditary and autosomal form predominantly occurs at a younger age and may present with limb shortening and deformity.

Conventional radiology (using anatomical location, transitional zone and mineralisation of matrix) is used to diagnose chondroid tumours[4]. When there is no mineralisation of the cortex, diagnosis becomes more difficult and Computer Tomography (CT) or Magnetic Resonance Imaging (MRI) may be used. MRI provides excellent demonstration of arterial and venous compromise [5]. The most common characteristics include: endosteal scalloping, thick periosteal reaction and cortical hook. Only symptoms caused by the tumour warrant surgical removal and can provide excellent results [6].

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3. Giant cell tumour of bone

Twenty per cent of all benign bone tumours are giant cell tumours (GCT), and mostly appear between the ages of 20 and 40 [7,8]. The location of GCTs can vary – most occur in the long bones,

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predominantly in the area of the knee (50–65%). Histologically, GCTs consist of giant cells with osteoclast like function surrounded by spindle-like stromal cells and other monocytic cells [7,9]. GCTs are usually benign (80%). However, recurrence after excision may occur in 20–50%, with 10% becoming malignant on recurrence [10].

GCTs appear on plain radiographs with the appearance of a lytic cystic lesion, with well defined, non-sclerotic margins [7,10]. These are usually located in the epiphysis of bones, with eccentric growth patterns. Other common features include cortical thinning, expansile remodelling of the bone, and prominent trabeculation [9]. In aggressive tumours radiographs may demonstrate cortical thinning, cortical bone destruction, and a wide zone of transition [9]. Pathologic fracture is a feature in between 11% and 37% of patients. [9,11]

Although GCTs are usually diagnosed on the basis of radiographic evidence, a number of additional imaging tools may help to confirm the diagnosis. In 57% of cases 'donut sign' is present on bone scintigraphy, a result of increased peripheral uptake of radionuclide [12].

The use of CT imaging is helpful in examining the extent of the tumour margins. CT is superior to radiographic imaging in the recognition of certain features of GCTs, including cortical alterations and periosteal reactions [9]. MR imaging is the most accurate tool for demonstrating GCTs margins [9,13]. However, it is less effective than CT imaging at demonstrating changes in the cortex of the bone [13].

Functional imaging tools such fluoro-2-deoxy-D-glucose positron emission tomography have been identified as a potentially useful tool in identifying malignancy in musculoskeletal tumours [14]. There has been less research into the usage of PET in identifying benign bone tumours [15]. There is some evidence demonstrating that in PET giant cell tumours and other tumours containing giant cells display high FDG uptake [15–17]. It has been suggested that FDG PET may therefore be useful in the imaging of giant cell tumours after recurrence, where normal anatomy may be distorted [18].

Primarily, the management of GCTs has been curettage followed by filling with bone cement [7,19]. However this has been associated with high recurrence rates. Additional treatment with adjuvants is often employed to reduce this recurrence. These adjuvants may include zinc chloride, bisphosphonates, phenol, liquid nitrogen and alcohol. [20–23]. Aggressive tumours may also be treated with wider excision and the use of surgical prostheses [9].

A recent development in treatment has been the use of the chemotherapy drug, denosumab, a monoclonal antibody which inhibits the osteoclastic activity of GCT [7]. This is useful when the location of the tumour makes surgery difficult, for example in the sacrum or pelvis [7]. Interim results of a phase II trial have shown that the drug may be used to reduce the need for more extensive surgery in difficult to resect tumours [24].

4. Osteoblastoma

Osteoblastoma is a rare, benign bone tumour accounting for 14% of bone tumours [25]. It most commonly affects people within the first four decades of life with a larger probability of it occurring in the second and third decades [26]. Although any bone can be involved, osteoblastoma arises predominantly in the axial skeleton with spinal lesions constituting one-third of reported cases [27]. On CT imaging, osteoblastoma appearance is changeable and can often look like other tumours, including malignant ones. They can be distinguished due to their significantly large nidus size (>2 cm in diameter, sometimes up to 15 cm) compared to osteoid osteoma [28], but diagnosis needs to be confirmed on biopsy. Their nidus is formed by dense sclerotic woven bone and tumour trabeculae frequently connect with the surrounding bone. Osteoblastoma tends to remain confined to bone and does not normally penetrate the cortex, it has therefore usually a good prognosis and a low recurrence rate of around 15–20% [29]. The first line of treatment is medical [30], if proven unsuccessful radiotherapy and chemotherapy might be attempted before choosing surgical interventions. There have only been a few cases reported where osteoblastoma has progressed to an osteosarcoma [31].

5. Osteoma

Osteomas are a benign outgrowth of membranous bones, most commonly found in the para-nasal sinuses, skull and long bones [32]. These benign tumours can grow on bone (homoplastic) and can present on other tissues (heteroplastic or eteroplastic) [33]. They consist of osseous tissue that comprises of condensed bone with a well-defined border, without surface irregularities or satellite lesions. Without symptoms they are difficult to diagnose. Because of their increased incidence in divers and swimmers an inflammatory response has been thought to be one of the underlying mechanisms [34]. Solitary osteoma are usually harmless, however if multiple are found they are a risk that the patient may have other underlying conditions, such as Gardner's syndrome [35]. Although rare, surgical removal is indicated in these circumstances as well as in symptomatic patients.

6. Osteoid osteoma

Rarely exceeding 1.5 cm, osteoid osteoma is a benign bone tumour composed of osteoid and woven bone. Osteoid osteoma makes up 12% of all skeletal neoplasms, making it quite common. 50% of osteoid osteoma lesions are found in the fibia or tibia. The cortex of long bones is the most common location of the lesion. Dense, fusiform, reactive sclerosis characterise osteoid osteoma [36]. It is more commonly found in young males under the age of 40 [37], whilst infants are rarely affected. The most common symptom is pain. The axial skeleton is affected much less, with skull and facial bones rarely affected. MRI, CT scanning and Isotopic scanning may be used for diagnoses and for the identification of central calcifications surrounded by the nidus (ovoid translucency) [26]. In a study done by Assoun et al. 19 patients were examined using CT and MRI, results showed that CT was more accurate than MR imaging in detection of the osteoid osteoma nidus in 63% of cases [38].

The osteoid and woven bone can be seen as interconnected trabeculae (thin or broad) or sheets. The bone surrounding the lesion (host bone) is strong and is made of varying mixtures of woven and lamellar bone [36]. The radiologic appearance of cortical osteoid osteoma arising in the shaft of a long bone has certain characteristics. It may be radiolucent and contain a changeable amount of mineralisation and is usually centrally positioned in an area of reactive osteosclerosis (dense fusiform, reactive). Sclerosis may regress after surgical removal of the tumour. Preoperative administration of tetracycline and the use of UV light for examination during the procedure may enhance the surgeon's view of the nidus. This technique works due to the tetracycline's position in the rapidly metabolised osteoid of the nidus in contrast to the slow mineralising host bone [36].

Out of 860 cases reviewed by Jackson et al. only 1.6% found it painless [39]. Most patients present with a swelling, mass or deformity. Swelling may be associated with superficial lesions.

Table shows the anatomical locations of the osteoid osteomas and their characteristics:

Morphological and anatomical location of Osteoid osteoma [40]	Characteristics
Intracortical	Dense sclerosis around the nidus
Periosteal	Periosteal reaction

Spongiosal	Produces very little reactive bone
Subarticular	Simulates arthritis as it produces synovial reactions

7. Aneurysmal bone cyst

Aneurysmal bone cysts (ABCs) are fairly rare benign cystic lesions, accounting for approximately 9.1% of all bone tumours [41]. The blood filled cysts are divided by connective tissue septa and contain a mix of osteoclasts, giant cells, and reactive woven bone [42–44]. Controversy exists as to the pathogenesis of aneurysmal bone cysts. In 30% of cases a predisposing lesion can be identified, a finding that some argue suggests that aneurysmal bone cysts are a reactive process to other pathological changes, rather than a distinct tumour type [42,44]. The most common pre-existing lesion is the giant cell tumour [44]. The sites most commonly associated with ABC are the femur, tibia, humerus and fibula, although they can present in other sites [42].

ABC appears on radiographs as radiolucent lesions of eccentric origin in the metaphysis of long bones [42]. The term 'soap bubble' is used to describe these lesions, a description which describes the erosion of the cortex of the bone and elevation of the periosteum [43]. CT imaging can be helpful in identifying the margins of the cyst [21]. MRI allows identification of the thin septa dividing the cyst, as well as demonstrating fluid-fluid levels within the cyst [42]. Biopsy and histological examination of the ABC is necessary to confirm the diagnosis [41,42].

There are a number of management options for ABCs. Curettage with bone grafting or resection and reconstruction for eccentric lesions has traditionally been used [43]. Curettage often involves adjuvant therapy to reduce the recurrence rate, which may be as high as 31% [41]. This may involve sclerotherapy [45] or cryotherapy, which has been shown to reduce the recurrence rate to 5% [46]. Embolization procedures, namely the injection of alcohol zein or selective arterial embolization, are highly controversial [41].

A number of novel potential treatments for ABC have recently been described in case studies. These treatments are less invasive and thus may offer an advantage over aggressive surgical options. The use of Denosumab as a therapeutic agent for the treatment of ABCs has been described in a study involving two patients with ABCs at C5, who both displayed tumour regression at 2 or 4 months [47]. However, more research in this area is required. New graft material such as autologous bone marrow mononuclear cells combined with B -tricalcium phosphate and atelocollagen has also resulted in ossification of the cyst in one patient [48]. These case studies show potential for resulting in innovative treatments for ABC, however more extensive trials are necessary before firm conclusions can be drawn.

8. Fibrous dysplasia

Fibrous dysplasia (FD) accounts for 5–7% of all benign bone tumours [49]. Fibrous dysplasia presents in two main forms – monostotic, affecting one bone, or polyostotic, which affects several bones. 75% of cases of fibrous dysplasia are of the monostotic form [50]. Monostotic fibrous dysplasia typically affects those in their 3rd decade of life, whist polyostotic presents in the 1st decade [51]. Polyostotic FD commonly affects the craniofacial bones, but may also affect the ribs, femur or tibia [51]. Fibrous dysplasia consists of fibrous stroma with a cellular component, with mutated fibroblast cells and osteoblasts of varying functionality, which produce abnormally shaped trabeculae of woven bone [51,52]. FD mostly becomes dormant as the affected child moves into adulthood, however there is a lifetime risk of malignant transformation that of around 1–4% [53].

FD appears radiographically as radiolucent areas which later develop into a partially opaque ground glass appearance [51]. Other features that may be present are endosteal scalloping, bony expansion, and a thick reactive bone 'rind' [54]. MR imaging may be a more effective tool at identifying the size of the area affected by FD, and could be useful when the radiographic appearance of suspected FD is ambiguous [54].

FD is usually treated conservatively by maintenance bone density with regular exercise and diet [50]. Medical therapy such as the use of bisphosphonates, particularly pamidronate, may be effective at reducing pain in FD, however there is a need for trials to provide further evidence of this effect [55]. It has been suggested that other medical therapies such as denosumab and pregabalin may be potentially useful treatments at reducing pain from FD [55]. Currently little evidence exists to support these hypotheses.

Surgery is considered in patients with progressive symptoms or when the disease threatens important anatomical structures [51]. Treatment is often curettage followed by autologous bone graft. Cortical bone grafts are deemed superior to cancellous bone grafts, by virtue of their ability to resist replacement by the FD lesion [49]. Where FD has resulted in deformity, corrective surgery may be required, for example osteotomy and intramedullary fixation [49,53]. Recurrence occurs in around 18% of cases [56].

9. Enchondroma

Only 2.6% of all benign bone tumours can be considered an enchondroma [52]. These asymptomatic tumours may present at any age, however 59% occur between the ages of 10 and 39 [52]. These tumours consist of masses of hyaline cartilage in a lobular formation, typically presenting in long tubular bones, most commonly the hands and feet [52,57]. These are usually solitary lesions, but it is possible for multiple enchondromas to form, a condition that is described as enchondromatosis or Ollier's disease [58].

During diagnosis it is essential to distinguish between a benign enchondroma and low grade chondrosarcoma. Enchondroma occurs more frequently in the hands and feet and chondrosarcoma in the axial skeleton – however accurate diagnosis is necessary given the different treatment routes required for both lesions [59]. Radiographic features of enchondromas include stippled calcification, endosteal scalloping, with areas of ossification or expanded cortex [52,57]. MRI allows identification of classic features of malignancy such as cortical destruction, soft tissue masses, multilocular appearance, and involvement of flat bone [60]. Cartilaginous islands surrounded by fat may also be a potentially useful diagnostic sign detected on MRI scans [61].

Enchondromas do not routinely require surgical treatment, unless they are symptomatic, increasing in size, or there is a risk of pathological fracture. Typically treatment of enchondromas has involved intralesional excision, followed by filling with an autologous bone graft or synthetic filling [57]. Adjuvant treatments have been used to reduce recurrence rates, however this is not normally necessary as 10 year recurrence is around 0.04% [57,62]. In recent years trials have suggested that curettage without augmentation or reconstruction is a potential new treatment [63]. This evidence suggests that the time for the formation of new bone is similar in groups of patients whether they receive grafts or undergo simple curettage [64]. A recent case series has suggested that a lateral approach during tumour excision, as opposed to the traditional dorsal approach may help to reduce postoperative stiffness [65].

Summary table

Type	Incidence (% of all benign bone tumours)	Diagnosis
Pathology features	Treatment	Recurrence rates
Osteochondroma	35	Radiograph, CT and MRI are useful, but biopsy is necessary to confirm diagnosis
Lesions occurring in metaphysis and diametaphysis and projects out of the underlying the bone	Surgery necessary if active or aggressive	< 2%
Giant cell tumour	20	Radiograph. CT or MR imaging may be useful
Soft, grey or red tumour often with small blood filled cysts	Necessary due to the risk of malignant transformation	20–50%
Osteoblastoma	14	Conventional radiology. MDCT plays a major role in identifying osseous matrix. CT or MRI may be helpful when there is no mineralisation of the cortex
Aneurysmal bone cyst may superimpose and may be associated with osteoblastoma. In long bones, periosteal reaction may be prominent	1st line: medical followed by controversial radio/ chemotherapy or surgical removal	9.8%
Osteoma	12.1	Radiograph, CT and MRI are useful, but biopsy is necessary to confirm diagnosis
Tosseous tissue that comprises of condensed bone with a well-defined border, without surface irregularities or satellite lesions	Surgery necessary if active or aggressive	N/A
Osteoid osteoma	10.8–13.5	Radiograph, CT and MRI are useful, but biopsy is necessary to confirm diagnosis
Intracortical osteoid osteoma produces dense sclerosis around the nidus. Subperiosteal type produces periosteal reaction while spongiosal type produces very little reactive bone.	Surgery necessary if active or aggressive	4.5%
Aneurysmal bone cyst	9.1	Radiograph, CT and MRI are useful, but biopsy is necessary to confirm diagnosis
Blood filled cavernous spaces with septa	Surgery necessary if active or aggressive	31%
Fibrous dysplasia	5–7	Radiograph. CT or MR imaging may be useful
Dense fibrous tissue with osteoid trabeculae	Surgery necessary if chronic bone pain consists after medical treatment, or if complicated by fractures	18%
Enchondroma	2.6	Radiograph, CT and MRI. Histologic evaluation necessary to exclude chondrosarcoma
Masses of hyaline cartilage in lobular formation	Consider if symptomatic or at risk of fracture	0.04%

10. Conclusion

Benign bone tumours are a group of neoplasms that are most frequent in children and young adults, although they may also present in later stages of life. They are most often diagnosed on the basis of radiographic evidence; however, CT and MRI imaging may be of some use in defining the extent of tumour spread locally. For the majority treatment is only indicated in symptomatic patients or if there is risk

of pathological fracture or deformity, with surgical intervention as most definite treatment option. Active treatment is usually only necessary in GTCs and aneurysmal bone cysts, due to their risk of malignancy. However, for most of the benign bone tumours there is no general consensus on standards of treatment, and the number of different adjuvants utilised in surgical treatments means recurrence rates vary widely.

Conflicts of interest statement

Authors report no conflicts of interest.

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